DOT/FAA/AR-04/14

Office of Aviation Research
Washington, DC 20591

# Shield Degradation Effects of Loosened Connector Backshells of Aircraft Wiring Harnesses

October 2004

Final Report

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U.S. Department of Transportation
**Federal Aviation Administration**

## NOTICE

**Technical Report Documentation Page**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| DOT/FAA/AR-04/14 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| SHIELD DEGRADATION EFFECTS OF LOOSENED CONNECTOR BACKSHELLS OF AIRCRAFT WIRING HARNESSES | October 2004 |
| | 6. Performing Organization Code |
| 7. Author(s) | 8. Performing Organization Report No. |
| J.B. O'Loughlin and S.R. Skinner | |
| 9. Performing Organization Name and Address | 1. Work Unit No. (TRAIS) |
| National Institute for Aviation Research<br>Wichita State University<br>1845 Fairmount Avenue<br>Wichita, KS 67260-0093 | 11. Contract or Grant No.<br>00-C-WSU-00-28 |
| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered |
| U.S. Department of Transportation<br>Federal Aviation Administration<br>Office of Aviation Research<br>Washington, DC 20591 | Final Report |
| | 14. Sponsoring Agency Code<br>AIR-100 |

15. Supplementary Notes

The FAA William J. Hughes Technical Center Technical Monitor was Anthony Wilson.

16. Abstract

Backshells of aircraft wiring harness connectors were loosened by percent torque and by degree turns to study the degrading effects on the electrical characteristics of the shielding these connectors provide.

For the two types of backshells studied, both became visually loose before any significant increase in harness loop resistance was measured. Therefore, careful visual inspection can detect and pinpoint the source of shield degradation before a significant increase in electrical shield loop resistance is measurable. However, a check for backshell visual looseness and hand looseness is only possible if the wiring harness connector backshells are visually and physically accessible on the aircraft. Otherwise, loop resistance measurements on any accessible part of the harness, performed by a skilled operator, can detect shield degradation but cannot pinpoint the location or source of the problem.

Due to the variance found in the test results between the two different types of backshells studied in this report, a further study is recommended in order to recommend maintenance procedures for a wide variety of aircraft connector backshells.

In addition to electrical loop resistance measurement techniques used to indicate the looseness of a connector backshell, visually loose and hand loose methods are also explicitly defined and studied in this report.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Backshell, Connector, Hand loose, Wiring harness, Loop resistance, Shield degradation, Thread loose, Visual inspection, Visually loose | This document is available to the public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. |

| 19. Security Classification (of this report) | 20. Security Classification (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 35 | |

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the technical assistance, guidance, and review given this study by Billy M. Martin, Charles B. Beuning, Michelle M. Cronkleton, and Michael D. Reilly of the Cessna Aircraft Company and Dr. Leland R. Johnson, Jr., Myrl W. Kelly, Jerry L. Tate, and Howard S. Jordan, Jr. of the Raytheon Aircraft Corporation, without their support this effort would not have been possible.

Special thanks is also given to Wichita State University graduate research assistants, Syed Ghayur, Ghulam Awan, Najma Begum, and Fayyaz Khan, who carefully and laboriously collected and organized the data, and professionally and methodically worked through numerous iterations and revisions to help produce this report.

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# EXECUTIVE SUMMARY

The connector backshell loosening research sponsored by the Federal Aviation Administration and conducted at the National Institute for Aviation Research was to study the degrading effects on the electrical characteristics of the shielding caused by loosening connector backshells. The test process involved three steps carried out on two different types of backshells, type A and type B.

In the first step, the loop resistance value and tightness of backshell for each test panel were recorded as pretest conditions. In the second and third steps, the backshells were loosened by degree turns and by torque specifications respectively. In addition to electrical measurement techniques used to indicate the looseness of a connector backshell, visually loose and hand-loose methods for visual inspection were explicitly defined and studied in this report.

The results of the backshell testing showed loosening of an aircraft wiring harness connector backshell will eventually result in a significant reduction of shield effectiveness as measured by a marked increase in the shield loop resistance of the wire bundle. Backshell types A and B became visually loose and hand loose before any significant increase in shield loop resistance was electrically measured. Careful visual inspection can detect and pinpoint a loose backshell before a significant increase in electrical shield loop resistance is measured. Checks for visual looseness and hand looseness were only possible if the wiring harness connector backshells are visually and physically accessible on the aircraft. Loop resistance measurements on an accessible part of a harness, performed by a skilled operator, can detect a significantly loose backshell, but may not pinpoint its location.

# 1. INTRODUCTION.

## 1.1 PURPOSE.

The purpose of this report is to document and evaluate the results of a connector backshell loosening study sponsored by the Federal Aviation Administration and conducted at the National Institute for Aviation Research.

## 1.2 TEST SETUP.

The tests were conducted to examine the degrading effects of loosening connector backshells, using two different backshell types (type A and type B), and to determine the resulting change in the electrical characteristics of the shielding. The tests were carried out on 8 out of 12 test panels; the remaining four test panels were not fit for testing because of degradation due to previous tests. Figure 1 shows a backshell type A test panel (Sunbank part number (P/N) S4785S16C12), and figure 2 shows a backshell type B test panel (Sunbank P/N S85049/25-22N). The same connector (P/N MS3475L16-26P) was used for both backshell types. Pretest conditions were recorded for each test panel to check the initial state of the backshells.

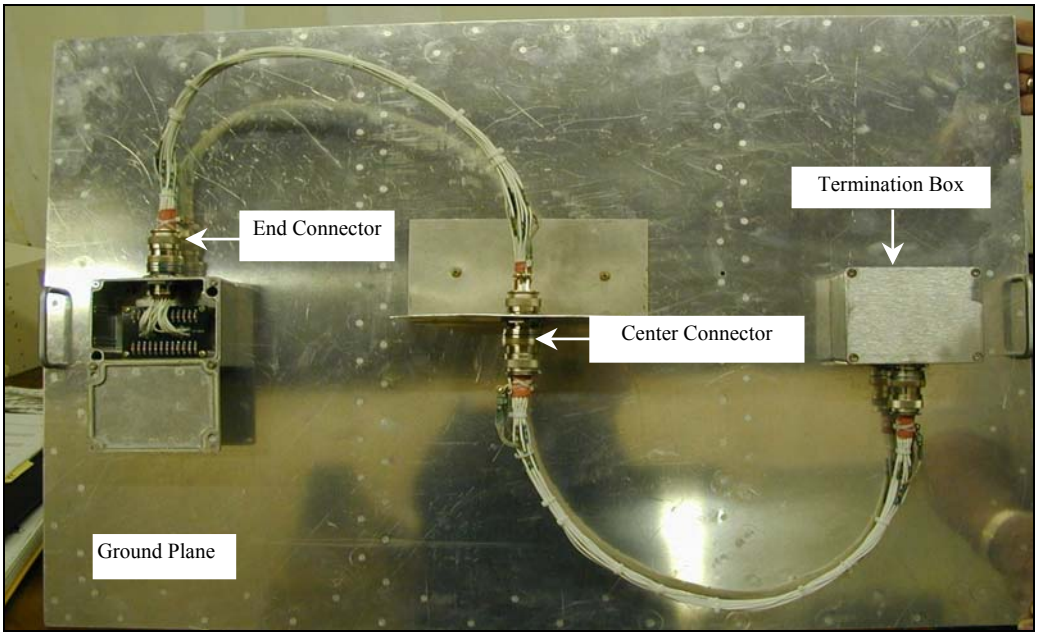


FIGURE 1. BACKSHELL TYPE A TEST PANEL

Loop resistance measurements for all test panels were taken with an Airbus loop resistance tester. The tests were carried out on all four backshells of each test panel; the individual loops (i.e., loops 1 and 2, rather than their sum) were selected for measurements. The following procedures were performed for this test sequence.

- Backshell pretest conditions
- Loosening of backshells by degree turn
- Loosening of backshells by torque specifications

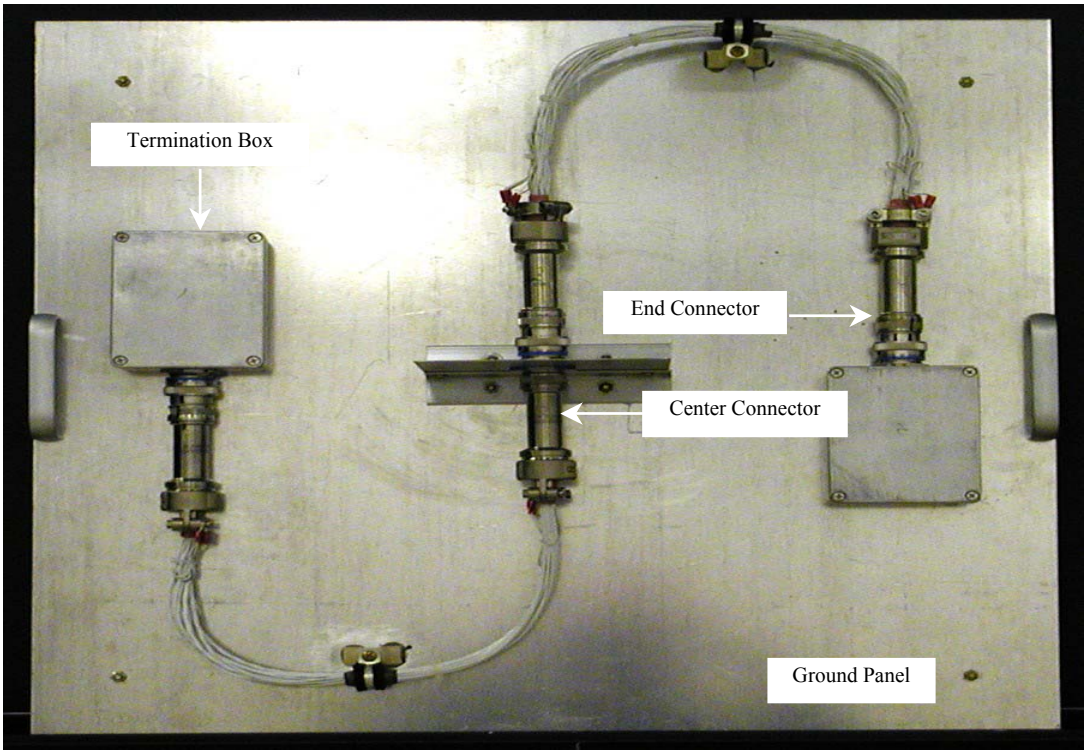


FIGURE 2. BACKSHELL TYPE B TEST PANEL

## 2. TEST PROCEDURE.

This backshell connector study was carried out to measure shield degradation as connector backshells were loosened. In addition to the electrical instrument techniques used to indicate the looseness of the backshell, visually loose, hand-loose, and thread-loose methods were also used. The following definitions were employed during the tests.

1. Thread-Loose Backshell. After torquing the backshell to the manufacturer's specification, the initial visible threads on the backshell were noted as a reference point. During different stages of the test, the backshell was observed, and as soon as an additional thread was clearly seen, the backshell was declared ***thread loose***, as shown in figure 3.

2. Visually Loose Backshell. After torquing the backshell to the manufacturer's specification, both the backshell and connector were marked as a reference to show the deviation of the backshell from the initial position. During different stages of the test, the backshell was observed, and as soon as there was a deviation from the marked reference point, it was declared ***visually loose***, as shown in figure 4.

3. Hand-Loose Backshell. Each backshell was torqued to the manufacturer's specification and connected to the test panel. They were then checked for hand looseness by applying a force in the opposite direction by hand. During different stages of the test, the hand force was applied after the backshell was fitted back on the test panel. As soon as the backshell was movable by hand, it was declared ***hand loose***.

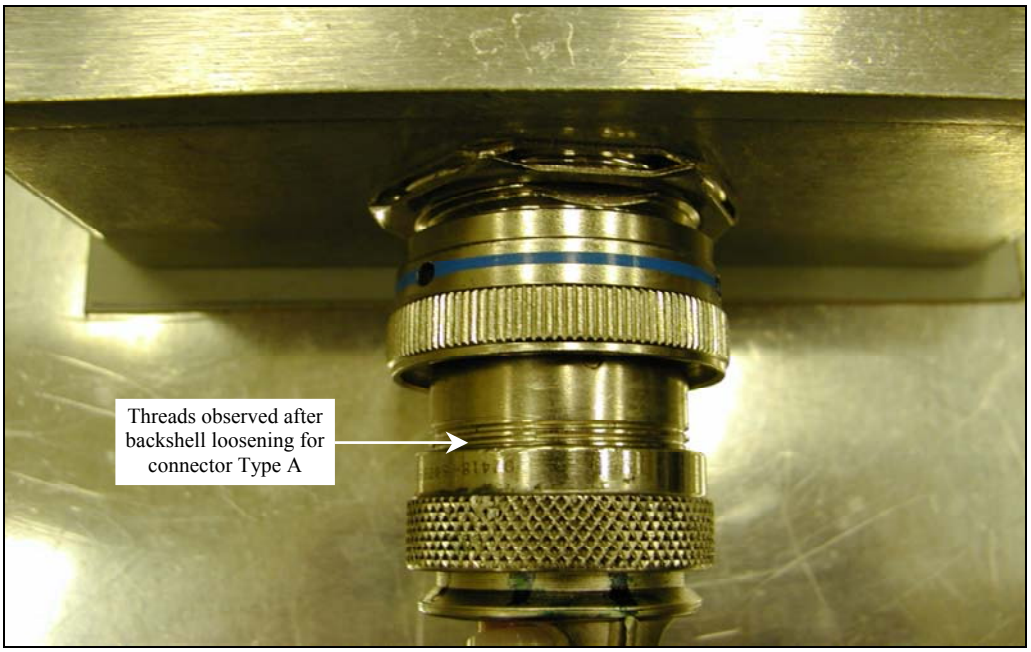


FIGURE 3. THREAD-LOOSE BACKSHELL

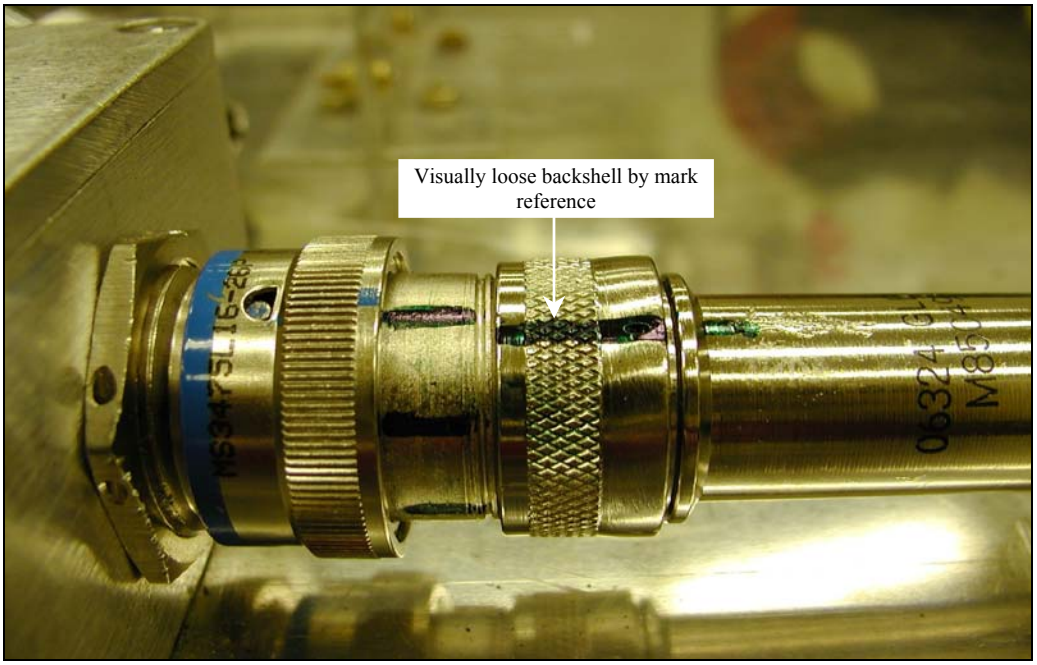


FIGURE 4. VISUALLY LOOSE BACKSHELL

The range of the force applied by hand was measured through experimentation using a torque wrench. A hand force was applied on the torque wrench in a manner similar to what was applied on the backshell during the test. The hand force was measured to be between 15 to 18 inch-pounds.

## 2.1 BACKSHELL PRETEST CONDITIONS.

A backshell pretest condition evaluation was performed to determine whether the backshells were over- or undertorqued compared to the manufacturer's specification. The initial state of the backshells of each panel was checked using the following steps.

1. The initial loop resistance measurements for loops 1 and 2 were taken and recorded as measurement 1.

2. The backshells were torqued to the manufacturer's specification and the degree of tightness for each backshell was recorded.

3. The loop resistance measurements for loops 1 and 2 were taken again and recorded as measurement 2.

4. All the backshells were loosened and then torqued to the manufacturer's specification, and the loop resistance measurements were taken again and recorded as measurement 3. This measurement was used as a baseline for further testing.

### 2.1.1 Results.

The backshell pretest conditions are listed in table 1 for backshell type A and in table 2 for backshell type B. Both tables show the pretests performed on each test panel, the loop resistance values for loops 1 and 2, and the degree of tightness (under- or overtorque) for each backshell.

After the altitude and temperature pretest was performed on test panel 1 of backshell type A, none of the backshells were found to be under- or overtorqued. There was no considerable change in loop resistance values for either loop, as shown by measurements 1, 2, and 3.

Test panel 3 was pretested for mechanical degradation, which affected loop 2 and was rendered it unfit for further testing (designated as not applicable (N/A). The loop resistance value for loop 1 remained consistent for all three measurements. Only backshell 1 was found to be undertorqued.

The vibration pretest was carried out on test panel 4. All the backshells were found to be undertorqued, as either a result of this test or as an initial condition. There was not much variation in the loop resistance values for either loop.

Measurements were not taken from test panel 6, which was not subjected to any of the pretests. Some variation was observed in the loop resistance values for both loops. All the backshells were observed to be undertorqued, except for backshell 2.

TABLE 1. PRETEST CONDITIONS (BACKSHELL TYPE A)

| Test Panel | Pretests | Airbus LRT Measurements (milliohms) | | | | Deviation From Specification (degrees) | | |
|---|---|---|---|---|---|---|---|---|
| | | Loop No. | Msrmt 1 | Msrmt 2 | Msrmt 3 | Backshell No. | Under-torque | Over-torque |
| 1 | Altitude and Temperature | 1 | 12.6 | 12.6 | 12.3 | 1 | 0 | 0 |
| | | | | | | 2 | 0 | 0 |
| | | 2 | 12.4 | 12.4 | 11.5 | 3 | 0 | 0 |
| | | | | | | 4 | 0 | 0 |
| 3 | Mechanical Degradation | 1 | 7.3 | 7.3 | 7.3 | 1 | 12 | 0 |
| | | | | | | 2 | 0 | 0 |
| | | 2 | N/A | N/A | N/A | 3 | N/A | N/A |
| | | | | | | 4 | N/A | N/A |
| 4 | Vibration | 1 | 7.3 | 7.2 | 7.2 | 1 | 24 | 0 |
| | | | | | | 2 | 12 | 0 |
| | | 2 | 7.8 | 7.6 | 7.6 | 3 | 12 | 0 |
| | | | | | | 4 | 12 | 0 |
| 6 | None | 1 | 10.8 | 6.1 | 7.1 | 1 | 30 | 0 |
| | | | | | | 2 | 0 | 0 |
| | | 2 | 11.2 | 7.1 | 7.9 | 3 | 24 | 0 |
| | | | | | | 4 | 24 | 0 |

TABLE 2. PRETEST CONDITIONS (BACKSHELL TYPE B)

| Test Panel | Pretests | Airbus LRT Measurements (milliohms) | | | | Deviation From Specification (degrees) | | |
|---|---|---|---|---|---|---|---|---|
| | | Loop No. | Msrmt 1 | Msrmt 2 | Msrmt 3 | Backshell No. | Under-torque | Over-torque |
| 1 | Altitude and Temperature | 1 | 83.3 | 81.8 | 81.1 | 1 | 12 | 0 |
| | | | | | | 2 | 6 | 0 |
| | | 2 | 70.9 | 70.7 | 70.7 | 3 | 0 | 0 |
| | | | | | | 4 | 0 | 0 |
| 3 | Mechanical Degradation | 1 | 37.5 | 25.4 | 25.4 | 1 | 18 | 0 |
| | | | | | | 2 | 0 | 0 |
| | | 2 | 41.2 | 30.6 | 30.8 | 3 | 24 | 0 |
| | | | | | | 4 | 30 | 0 |
| 4 | Vibration | 1 | N/A | N/A | N/A | 1 | N/A | N/A |
| | | | | | | 2 | N/A | N/A |
| | | 2 | 42.5 | 29.7 | 29.7 | 3 | 6 | 0 |
| | | | | | | 4 | 18 | 0 |
| 6 | None | 1 | 23.4 | 18.5 | 18.7 | 1 | 30 | 0 |
| | | | | | | 2 | 0 | 0 |
| | | 2 | 20.4 | 21.8 | 21.8 | 3 | 18 | 0 |
| | | | | | | 4 | 24 | 0 |

After the altitude and temperature pretest was performed on test panel 1 of backshell type B, only backshells 1 and 2 were found to be undertorqued. There was no significant change in loop resistance values for either loop, as seen from measurements 1, 2, and 3.

Test panel 3 was pretested for mechanical degradation. Loop resistance values for both loops showed some variation between measurements 1 and 2, but there was not much difference between measurements 2 and 3. All the backshells were observed to be undertorqued, except for backshell 2.

The vibration pretest was carried out on test panel 4. Loop 1 was damaged by this test and was rendered unfit for further testing. Loop resistance values for loop 2 showed some variation between measurements 1 and 2, but there was no change between measurements 2 and 3. Backshells 3 and 4 were found to be undertorqued.

Measurements were taken from test panel 6, which was not subjected to any of the pretests. Backshells 1, 3, and 4 were found to be undertorqued. Resistance values for both loops showed some variation between measurements 1 and 2, but there was not much difference between measurements 2 and 3.

### 2.1.2 Observations.

The following observations are based on the pretest results.

- None of the connector backshells were found to be overtorqued. Many were found to be undertorqued due to the pretests or initial conditions.
- Undertorqued backshells showed a decrease in loop resistance value when they were torqued to the manufacturer's specification. The loop resistance value remained the same for the rest of the backshells.

## 2.2 LOOSENING OF BACKSHELL BY DEGREE TURNS.

The following steps were performed on each individual loop of the test panel.

1. Record the loop resistances for loops 1 and 2, as shown in tables 3 and 4, and set the baseline loop resistance value.
2. All the backshells and connectors were marked at 0°, 45°, 90°, and 180°, as shown in figure 5, to facilitate backshell loosening over a set of degrees.
3. The first backshell of each loop was loosened to 45°, as shown in figure 5. The loop resistance was measured and recorded. A visual inspection, including a check for hand looseness, was performed, and the observations were recorded.
4. The second backshell of each loop was loosened to 45°, with the observations recorded as described in step 3.
5. Steps 3 and 4 were repeated for 90°, 180°, 360°, 540°, and 720° (see figures 6 and 7) until the loop resistance of both loops reached an open circuit.

TABLE 3. CONNECTOR BACKSHELL LOOSENING BY DEGREE TURNS (BACKSHELL TYPE A)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell Degree Turn | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 1 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 2 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | | | 12.3 | 12.1 | 12.2 | 12.2 | 11.7 | 11.8 | 12.1 | 11.6 | 13.4 | 23.3 | 27.6 | ∞ | ∞ |
| | | | | N | N | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y |
| | | | | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | 2 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 3 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 4 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | | | 11.5 | 11.7 | 11.9 | 12.2 | 12.7 | 12.8 | 12.8 | 14.3 | 16.3 | 25.6 | 35.5 | ∞ | ∞ |
| | | | | N | N | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y |
| | | | | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| 3 | 1 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 1 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 2 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | | | 7.3 | 7.1 | 7.2 | 7.2 | 7.4 | 7.5 | 7.6 | 7.7 | 7.9 | 8.9 | 19.2 | ∞ | ∞ |
| | | | | N | N | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y |
| | | | | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | 2 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 3 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 4 | baseline | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | - | - | - | - | - | - | - | - | - | - | - | - | - |

TABLE 3. CONNECTOR BACKSHELL LOOSENING BY DEGREE TURNS (BACKSHELL TYPE A) (Continued)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell Degree Turn | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 1 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 2 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | | | 7.2 | 7.4 | 7.6 | 8 | 8.1 | 8.1 | 9.7 | 9.6 | 15.4 | 20.5 | 87 | ∞ | ∞ |
| | | | | N | N | N | N | N | N | N | Y | Y | Y | Y | Y | Y |
| | | | | N | N | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y |
| | 2 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 3 | baseline | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | 4 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | | 7.6 | 7.4 | | 7.6 | | 7.6 | | 12.6 | | 16.8 | | ∞ | |
| | | | | N | N | | N | | N | | Y | | Y | | Y | |
| | | | | N | N | | N | | Y | | Y | | Y | | Y | |
| 6 | 1 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 1 | baseline | 45 | | 90 | | 180 | | 360 | | 540 | | 720 | |
| | | | 2 | baseline | - | | - | | - | | - | | - | | - | |
| | | | | 7.1 | 7.2 | | 7.4 | | 7.4 | | 7.4 | | 8.2 | | ∞ | |
| | | | | N | N | | N | | Y | | Y | | Y | | Y | |
| | | | | N | N | | Y | | Y | | Y | | Y | | Y | |
| | 2 | Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N) | 3 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 4 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | | | 7.9 | 8 | 7.9 | 8.1 | 8.2 | 8 | 6.9 | 6.8 | 6.9 | 6.7 | 24.3 | ∞ | ∞ |
| | | | | N | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| | | | | N | N | N | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

TABLE 4. CONNECTOR BACKSHELL LOOSENING BY DEGREE TURNS (BACKSHELL TYPE B)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell Degree Turn | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Airbus LRT (m Ω) | 1 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 2 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | Thread Loose (Y/N) | | 81.1 | 88.1 | 94.7 | 103.4 | 101 | ∞ | ∞ | | | | | | |
| | | Hand Loose (Y/N) | | N | N | N | Y | Y | Y | Y | | | | | | |
| | | | | N | N | N | Y | Y | Y | Y | | | | | | |
| | 2 | Airbus LRT (m Ω) | 3 | baseline | - | | - | | - | | - | | - | | - | |
| | | | 4 | baseline | 45 | | 90 | | 180 | | 360 | | 540 | | 720 | |
| | | Thread Loose (Y/N) | | 70.7 | 75.8 | | 95.3 | | ∞ | | ∞ | | | | | |
| | | Hand Loose (Y/N) | | N | N | | Y | | Y | | Y | | | | | |
| | | | | N | Y | | Y | | Y | | Y | | | | | |
| 3 | 1 | Airbus LRT (m Ω) | 1 | baseline | 45 | | 90 | | 180 | | 360 | | | | | |
| | | | 2 | baseline | - | | - | | - | | - | | | | | |
| | | Thread Loose (Y/N) | | 25.4 | 28.8 | | 31.6 | | ∞ | | ∞ | | | | | |
| | | Hand Loose (Y/N) | | N | N | | Y | | Y | | Y | | | | | |
| | | | | N | Y | | Y | | Y | | Y | | | | | |
| | 2 | Airbus LRT (m Ω) | 3 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 4 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | Thread Loose (Y/N) | | 30.8 | 37.8 | 40.7 | ∞ | ∞ | | | | | | | | |
| | | Hand Loose (Y/N) | | N | N | N | Y | Y | | | | | | | | |
| | | | | N | Y | Y | Y | Y | | | | | | | | |

TABLE 4. CONNECTOR BACKSHELL LOOSENING BY DEGREE TURNS (BACKSHELL TYPE B) (Continued)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell Degree Turn | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | Airbus LRT (m Ω) | 1 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 2 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | Thread Loose (Y/N) | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | Hand Loose (Y/N) | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | 2 | Airbus LRT (m Ω) | 3 | baseline | - | - | - | - | - | - | - | - | - | - | - | - |
| | | | 4 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | Thread Loose (Y/N) | | 29.7 | 29.8 | 30.1 | 31.3 | 37.5 | ∞ | ∞ | | | | | | |
| | | Hand Loose (Y/N) | | N | N | N | N | N | Y | Y | | | | | | |
| | | | | N | Y | Y | Y | Y | Y | Y | | | | | | |
| 6 | 1 | Airbus LRT (m Ω) | 1 | baseline | 45 | | 90 | | 180 | | 360 | | 540 | | 720 | |
| | | | 2 | baseline | baseline | | - | | - | | - | | - | | - | |
| | | Thread Loose (Y/N) | | 18.7 | 26.7 | | 27.5 | | 29.8 | | ∞ | | ∞ | | | |
| | | Hand Loose (Y/N) | | N | N | | N | | Y | | Y | | Y | | | |
| | | | | N | N | | Y | | Y | | Y | | Y | | | |
| | 2 | Airbus LRT (m Ω) | 3 | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 | 720 |
| | | | 4 | baseline | baseline | 45 | 45 | 90 | 90 | 180 | 180 | 360 | 360 | 540 | 540 | 720 |
| | | Thread Loose (Y/N) | | 21.8 | 23 | 23.8 | 24.8 | 25 | ∞ | ∞ | | | | | | |
| | | Hand Loose (Y/N) | | N | N | N | Y | Y | Y | Y | | | | | | |
| | | | | N | Y | Y | Y | Y | Y | Y | | | | | | |

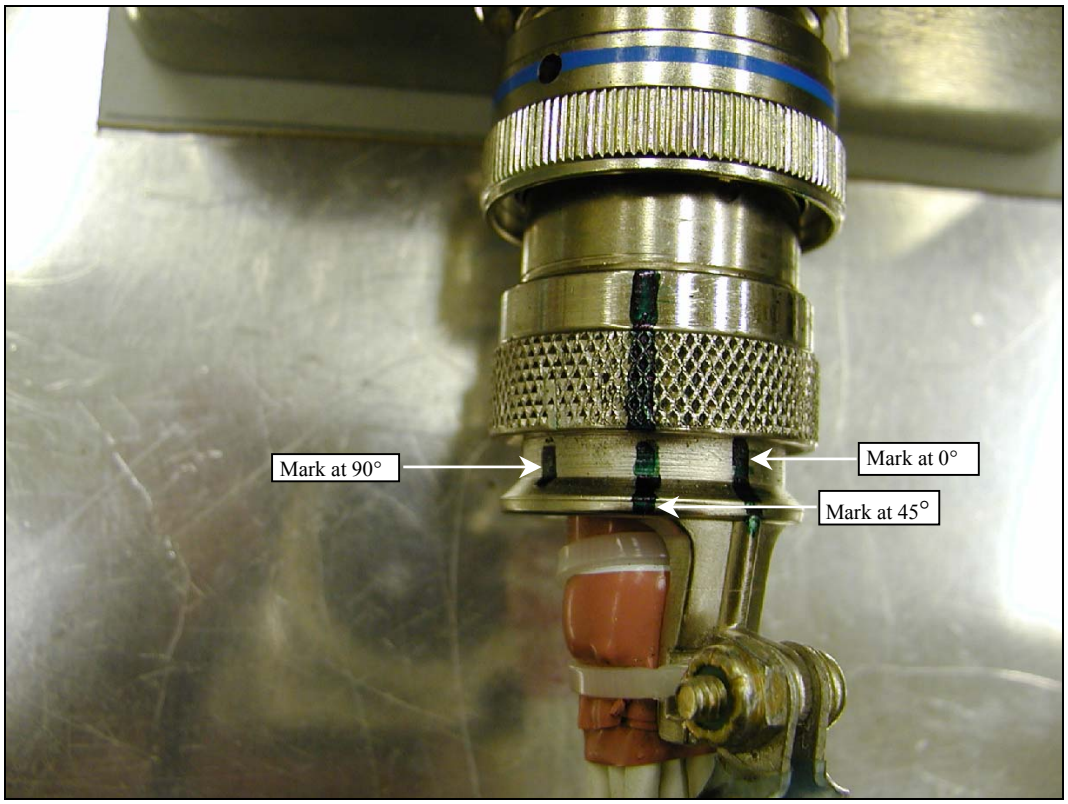


FIGURE 5. MARKINGS ON CONNECTOR BACKSHELL

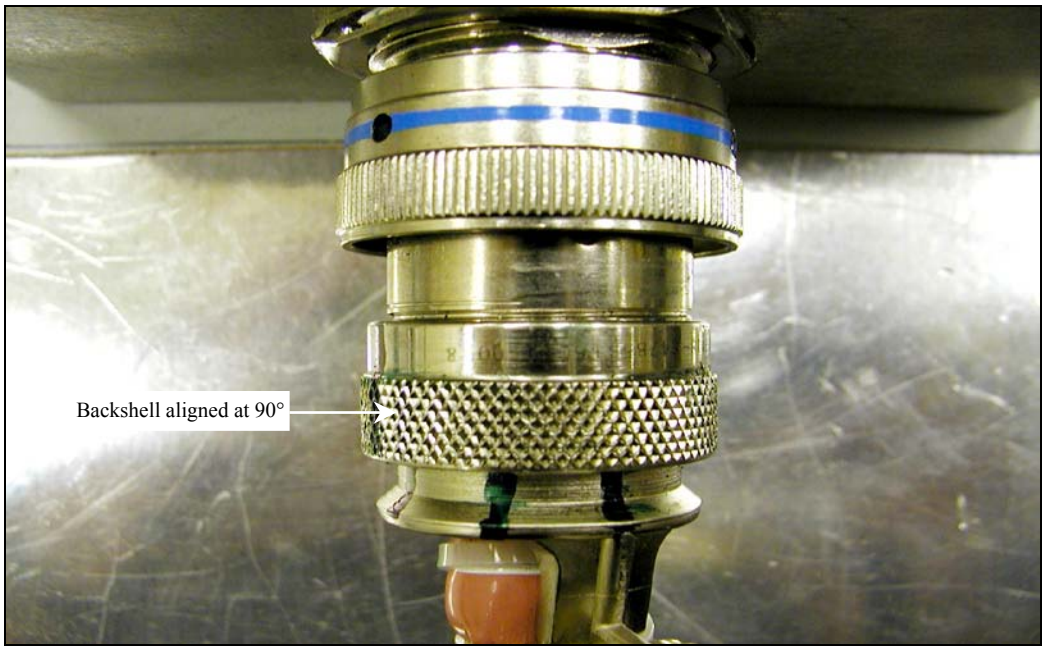


FIGURE 6. BACKSHELL ALIGNED AT 90°

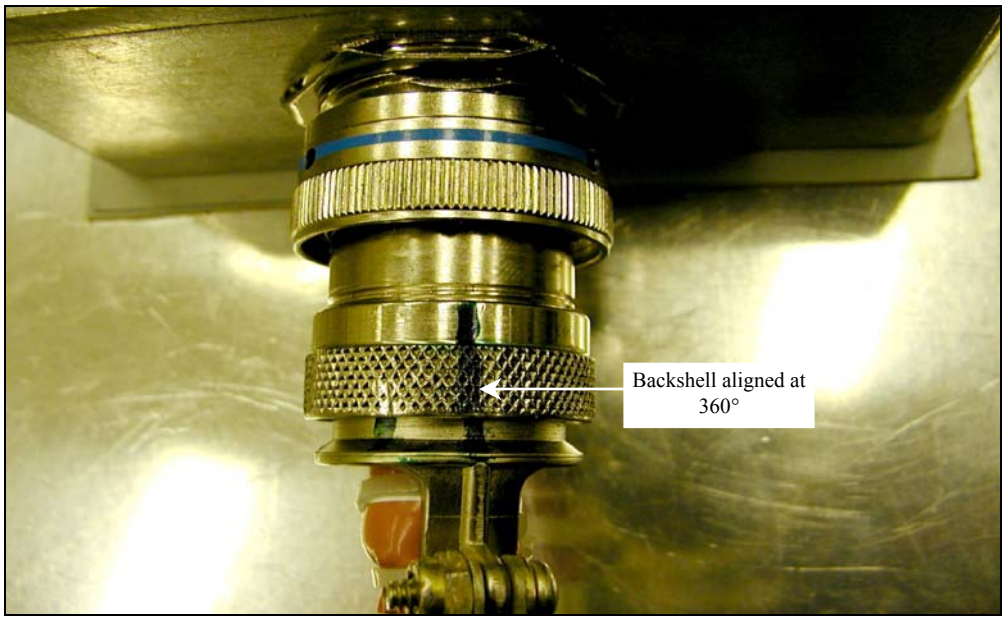


FIGURE 7. BACKSHELL ALIGNED AT 360°

The results of the tests are shown in table 3 for backshell type A and in table 4 for backshell type B. The first column for both tables lists the test panel number, while the loop number of each test panel is given in the second column. The measurement techniques are listed in the third column, and the fourth column lists the backshell number. The two backshells of each loop were loosened one after the other to the specified degree turns, as shown in the last column of the tables. The corresponding values for all the measurement techniques are also recorded in this column.

All the test panels of backshell type A were found to be visually loose when the respective backshells were loosened to 45°. Test panel 1 of backshell type A was found to be hand loose at 90° and thread loose at 180°. The loop resistance values were recorded until it went out of range (∞) at 720° for both loops. Test panel 3 was found to be hand loose at 90° and thread loose at 180°. The loop resistance values were recorded until they went out of range at 720° for both loops. There were no measurements taken for loop 2, indicated as (-) in the table, because it was not fit for further testing (see pretest conditions). Test panel 4 was found to be hand loose at 180° and thread loose at 360°. The loop resistance values were recorded until it went out of range at 720° for both loops. Test panel 6 of backshell type A was found to be hand loose at 90° and thread loose at 180°. The loop resistance values were recorded until it went out of range at 720° for both loops.

Figures 8 through 11 are graphs of degree of loosening versus loop resistance for each test panel of backshell type A. Resistance values for loops 1 and 2 are plotted separately for each test panel. Arrows illustrate the observations for visually loose, hand loose, and thread loose. The loop resistance value going out of range is also highlighted with an arrow. Loosening of backshells eventually resulted in a significant reduction of shield effectiveness, as shown by an increase in the loop resistance. The backshells of all the test panels became visually loose before they were observed to be hand loose or thread loose. The loop resistance value increased

abruptly after the backshell was loosened to 360° and went out of range at 540°. The backshells were detected as visually loose prior to any abrupt increase in the loop resistance value. The backshells were also detected as hand loose or thread loose prior to or at any abrupt increase in the loop resistance value. Thread looseness is a subjective technique because it requires prior knowledge of the number of threads that were visible at the 100% torque specification.

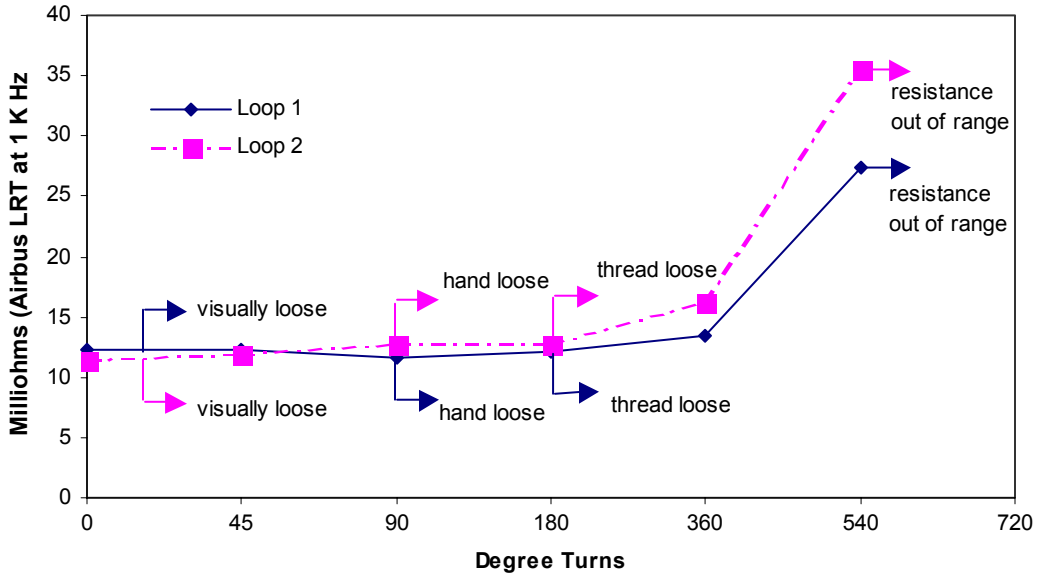


FIGURE 8. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 1 (BACKSHELL TYPE A)

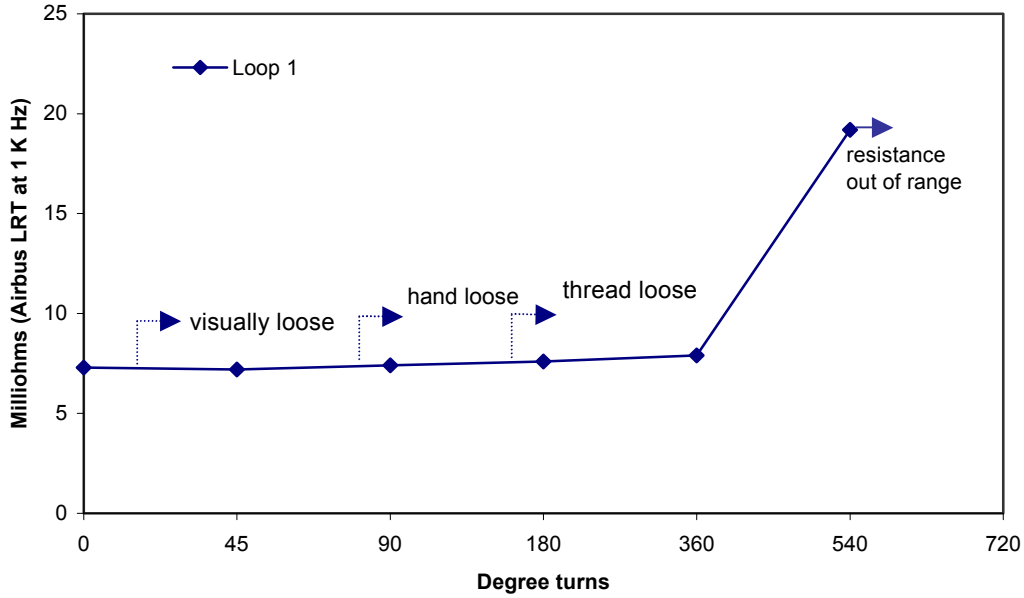


FIGURE 9. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 3 (BACKSHELL TYPE A)

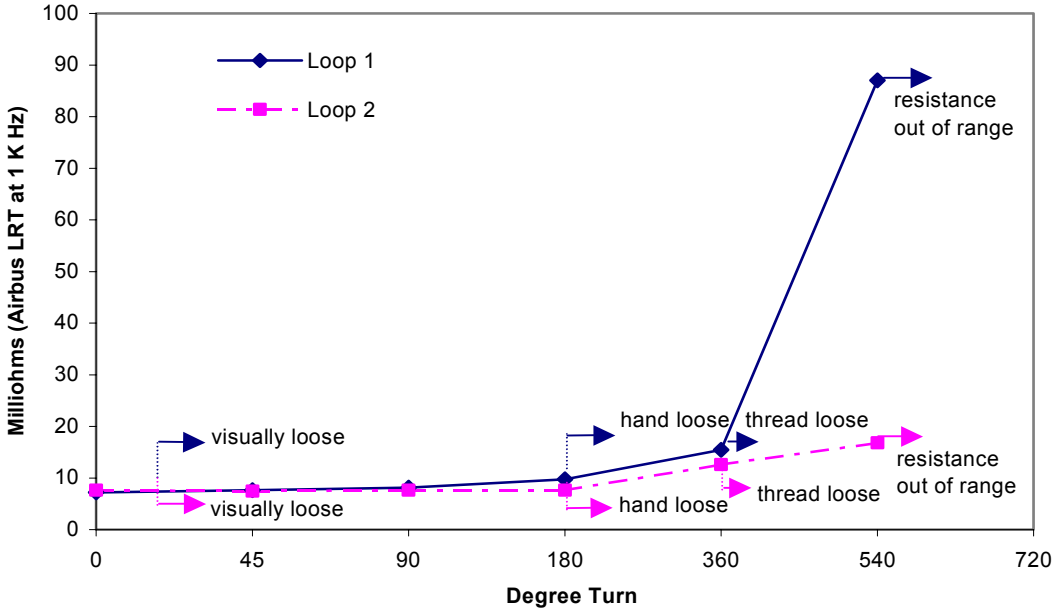


FIGURE 10. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 4 (BACKSHELL TYPE A)

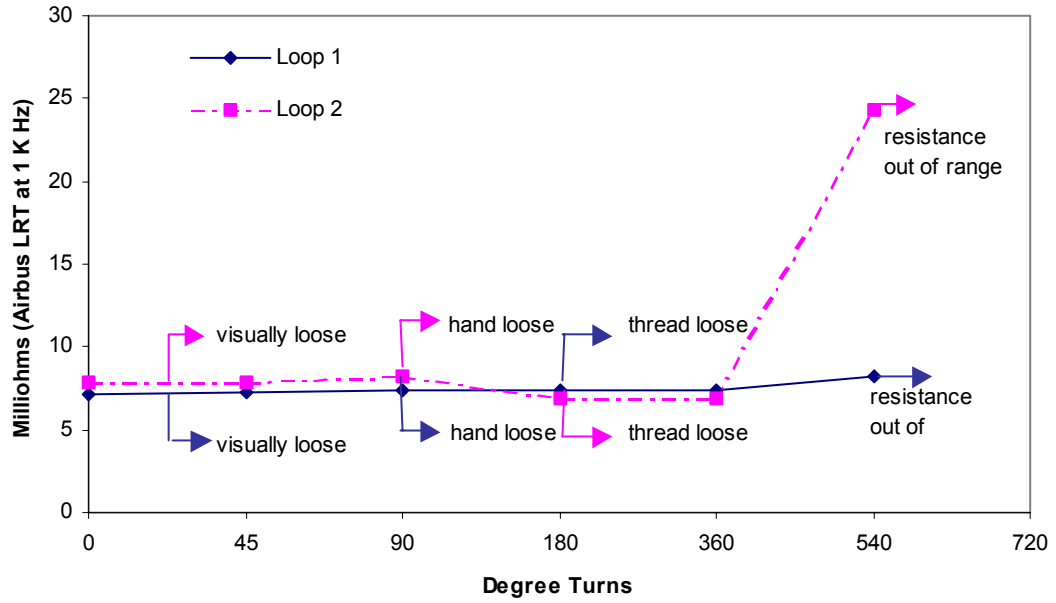


FIGURE 11. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 6 (BACKSHELL TYPE A)

All the test panels of backshell type B were also found to be visually loose when the respective backshells were loosened to 45°. Loop 1 of test panel 1 was found to be hand loose and thread loose when the backshell was loosened to 90°. The loop resistance values were recorded until it

went out of range (∞) at 180°. Loop 2 became hand loose at 45° and was observed to be thread loose at 90°. The loop resistance values were recorded until it went out of range at 180°. Test panel 3 was found to be hand loose when the backshell of loops 1 and 2 were loosened to 45° and was observed to be thread loose at 90°. The loop resistance values were recorded until it went out of range at 180° and 90° for loops 1 and 2 respectively. There were no measurements taken for loop 1 of test panel 4, indicated as (-) in the table, because it was not fit for further testing (see pretest conditions). Loop 2 was found to be hand loose when the backshell was loosened to 45° and thread loose at 180°. The loop resistance values were recorded until it went out of range at 180°. Loop 1 of test panel 6 was found to be hand loose at 90° and thread loose at 180°. Loop 2 was found to be hand loose at 45° and thread loose at 90°. The loop resistance values were recorded until it went out of range at 360° for loop 1 and at 180° for loop 2.

Figures 12 through 15 are graphs of degree of loosening versus loop resistance for each test panel of backshell type B. Resistance values for loops 1 and 2 are plotted separately for each test panel. Arrows illustrate the observations for visually loose, hand loose, and thread loose. The loop resistance value going out of range is also highlighted with an arrow. Loosening of backshells eventually resulted in a significant reduction of shield effectiveness, as measured by an increase in the loop resistance. The backshells of all the test panels became visually loose before they were observed to be hand loose or thread loose. The loop resistance values increased abruptly and went out of range after the backshells were loosened to 90°. The backshells were detected as visually loose prior to any abrupt increase in the loop resistance value. The backshells were also detected as hand loose or thread loose prior to or at any abrupt increase in the loop resistance value. Thread looseness is a subjective technique because it requires prior knowledge of the number of threads that were visible at the 100% torque specification.

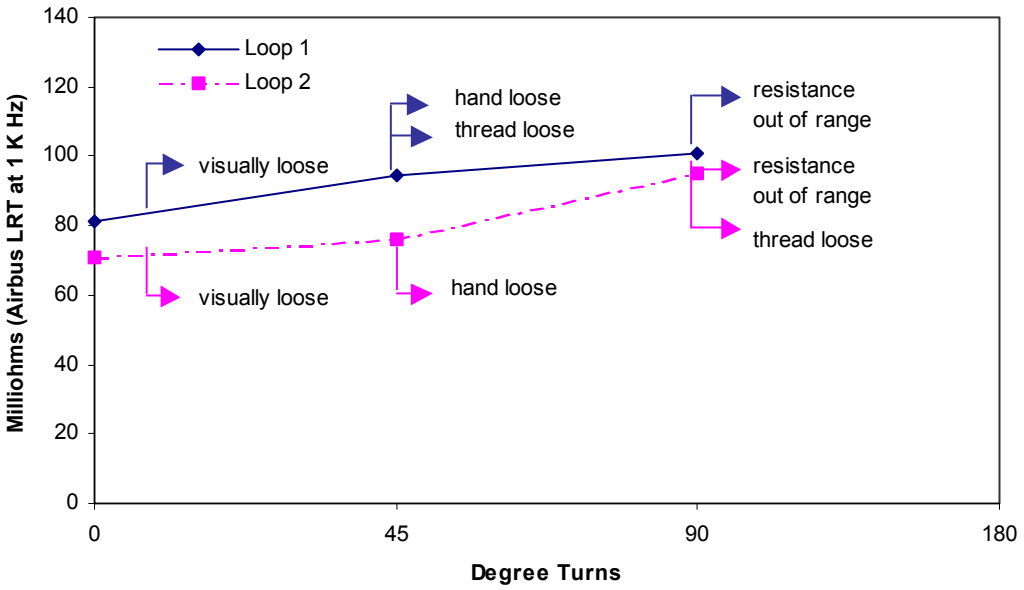


FIGURE 12. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 1 (BACKSHELL TYPE B)

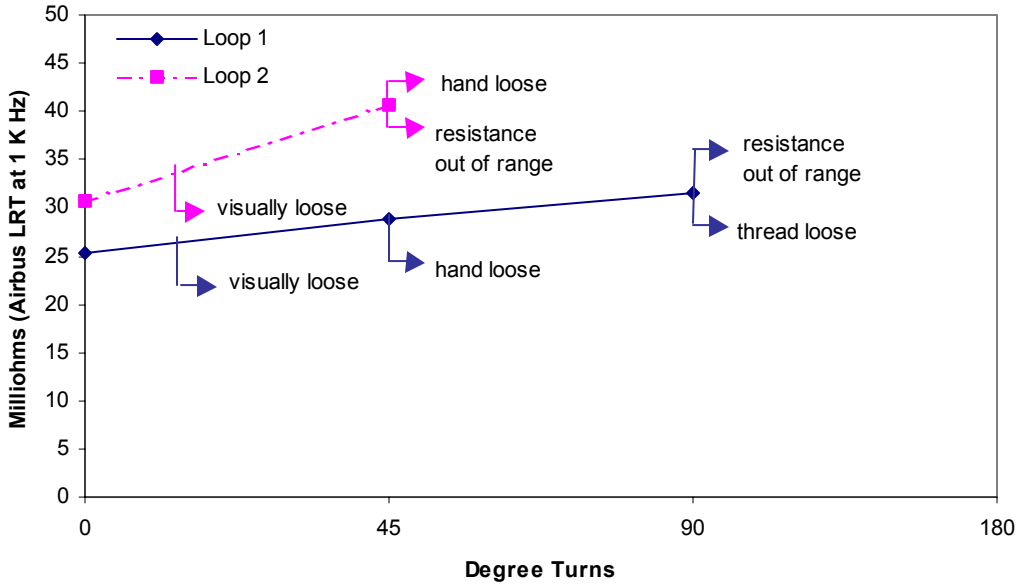


FIGURE 13. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 3 (BACKSHELL TYPE B)

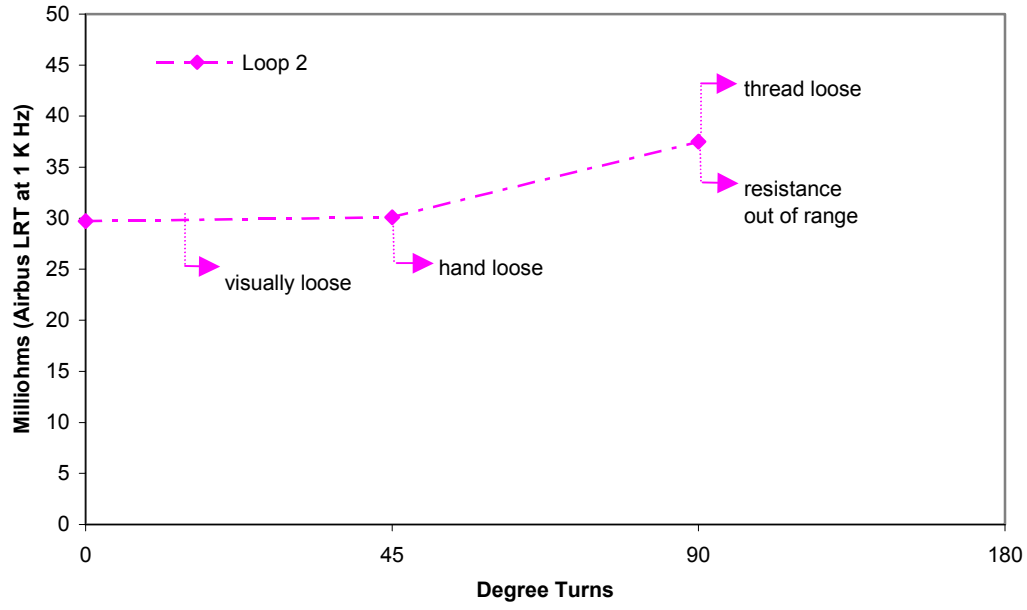


FIGURE 14. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 4 (BACKSHELL TYPE B)

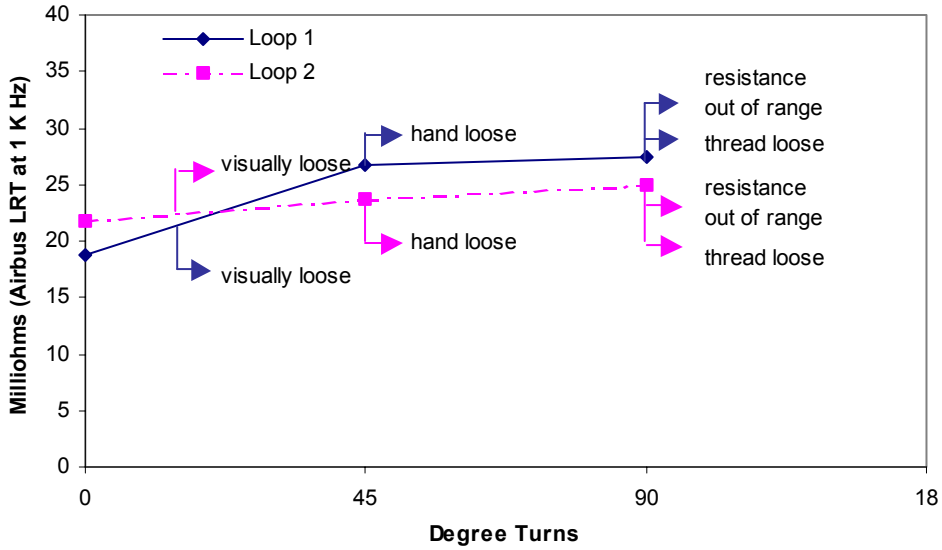


FIGURE 15. BACKSHELL LOOSENING BY DEGREE TURNS—TEST PANEL 6 (BACKSHELL TYPE B)

## 2.3 LOOSENING OF BACKSHELLS BY TORQUE SPECIFICATION.

The following steps were carried out for each loop of each panel tested.

1. The two backshells were tightened to the manufacturer's specification and baseline measurements were taken for individual loops (figure 16). This step, and the following steps, were repeated twice for precision.

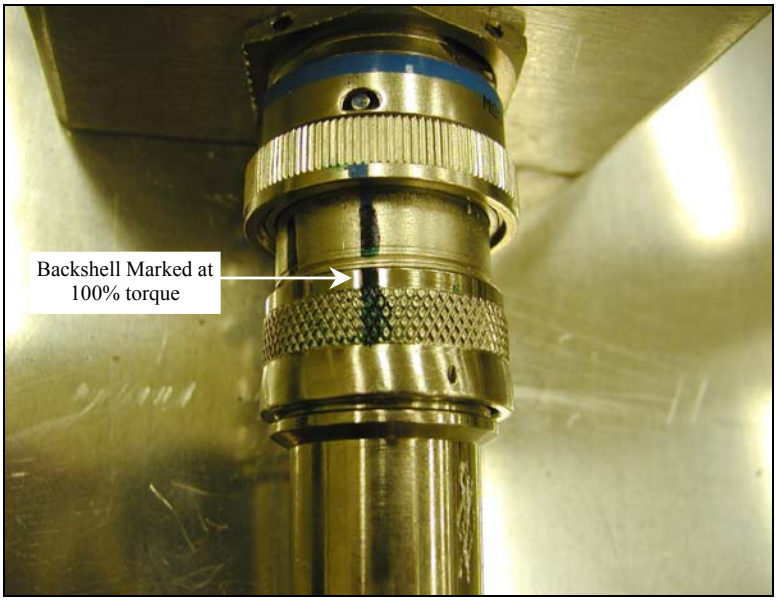


FIGURE 16. BACKSHELL TORQUED TO MANUFACTURER'S SPECIFICATION (BASELINE)

2. The backshells were loosened to open circuit, and then tightened to 75 percent of the torque specification, as shown in figure 17. The loop resistance and visual observations, including a hand check for looseness, were recorded.

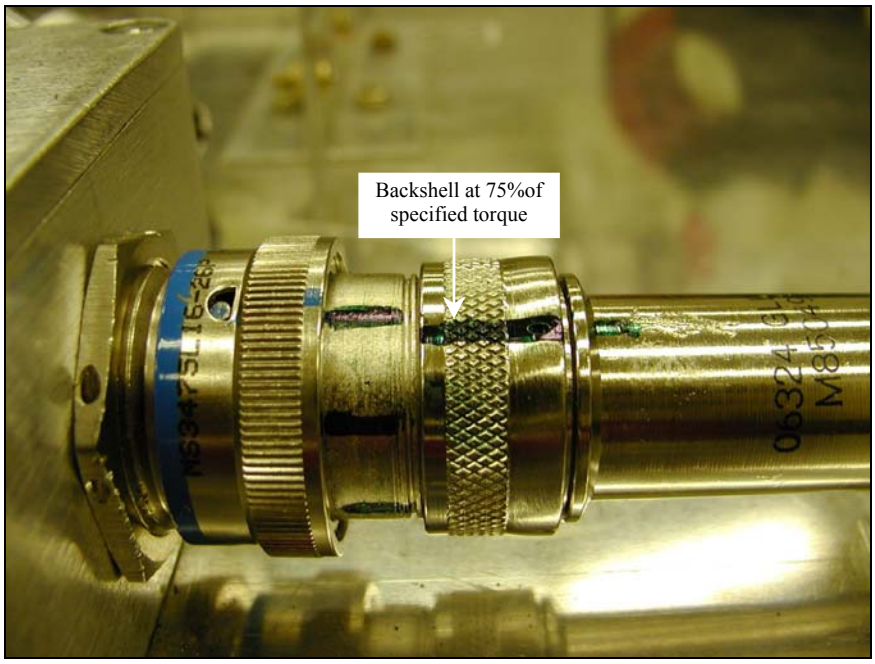


FIGURE 17. BACKSHELL AT 75% OF SPECIFIED TORQUE

3. Step 2 was repeated for 50% (figure 18), 25%, and 10% of the torque specification.

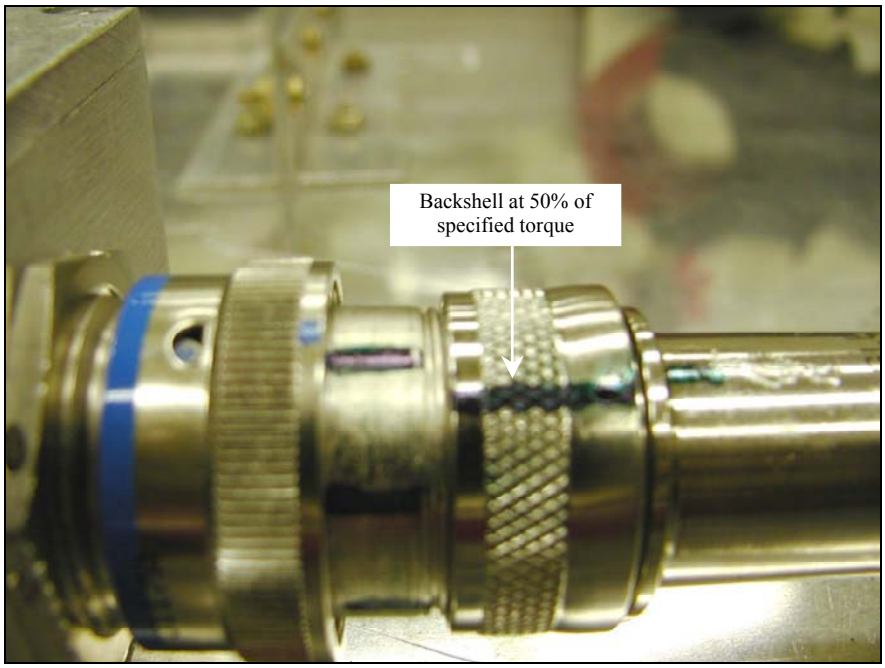


FIGURE 18. BACKSHELL AT 50% OF SPECIFIED TORQUE

2.3.1 Results.

The results of the tests are shown in table 5 for backshell type A and in table 6 for backshell type B. The first column for both tables lists the test panel number, while the loop number of each test panel is provided in the second column. The measurement techniques are listed in the third column, and the fourth column lists the backshell number. The two backshells of each loop were torqued to different percentages of the manufacturer's torque specifications. These torques in conjunction with their respective values for all techniques given in the third column are recorded in the last column. The average loop resistance values for each torque specification are shown in the last column.

TABLE 5. CONNECTOR BACKSHELL LOOSENING BY TORQUE SPECIFICATION (BACKSHELL TYPE A)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell (Percentage of Torque Specified) | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Avg. Airbus LRT (m Ω) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 11.2 | 12 | 11.4 | 12.3 | 12.1 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle Offset (degrees) | | N | N | N | N | Y |
| | | Angle Offset (degrees) | 1 | 0 | 12 | 12 | 24 | 90 |
| | | | 2 | 0 | 12 | 18 | 30 | 96 |
| | 2 | Avg. Airbus LRT (m Ω) | 3 | 100% | 100% | 100% | 100% | 100% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 10.9 | 11.8 | 12.4 | 12.03 | 12.2 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle Offset (degrees) | | N | N | N | N | Y |
| | | Angle Offset (degrees) | 3 | - | - | - | - | - |
| | | | 4 | 0 | 6 | 6 | 36 | 72 |
| 3 | 1 | Avg. Airbus LRT (m Ω) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 7.26 | 7.4 | 7.5 | 7.65 | 7.85 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle Offset (degrees) | | N | N | N | N | Y |
| | | Angle Offset (degrees) | 1 | 0 | 0 | 12 | 30 | 54 |
| | | | 2 | 0 | 6 | 6 | 36 | 78 |
| | 2 | Avg. Airbus LRT (m Ω) | 3 | 100% | 100% | 100% | 100% | 100% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | - | - | - | - | - |
| | | Hand Loose (Y/N) | | - | - | - | - | - |
| | | Angle Offset (degrees) | | - | - | - | - | - |
| | | Angle Offset (degrees) | 3 | - | - | - | - | - |
| | | | 4 | - | - | - | - | - |

TABLE 5. CONNECTOR BACKSHELL LOOSENING BY TORQUE SPECIFICATION (BACKSHELL TYPE A) (Continued)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell (Percentage of Torque Specified) | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 1 | Avg. Airbus LRT (m Ω) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 7.35 | 7.35 | 7.35 | 7.5 | 7.6 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle offset (degrees) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 1 | 0 | 6 | 12 | 42 | 180 |
| | | | 2 | 0 | 6 | 12 | 36 | 120 |
| | 2 | Avg. Airbus LRT (m Ω) | 3 | 100% | 100% | 100% | 100% | 100% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 7.25 | 7.5 | 7.75 | 7.83 | 7.95 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle offset (degrees) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 3 | - | - | - | - | - |
| | | | 4 | 0 | 12 | 24 | 42 | 180 |
| 6 | 1 | Avg. Airbus LRT (m Ω) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 100% | 100% | 100% | 100% |
| | | Thread Loose (Y/N) | | 6.15 | 6.3 | 6.25 | 6.4 | 6.72 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle offset (degrees) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 1 | 0 | 0 | 6 | 36 | 72 |
| | | | 2 | - | - | - | - | - |
| | 2 | Avg. Airbus LRT (m Ω) | 3 | 100% | 75% | 50% | 25% | 10% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Thread Loose (Y/N) | | 7.55 | 7.0 | 6.95 | 7.0 | 7.6 |
| | | Hand Loose (Y/N) | | N | N | N | N | N |
| | | Angle offset (degrees) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 3 | 0 | 6 | 18 | 42 | 90 |
| | | | 4 | 0 | 0 | 6 | 42 | 102 |

All type A backshells, except for backshell 1 of test panel 6, were found to be visually loose at 75% of torque specification. Backshell 1 of the above-mentioned test panel was found to be visually loose at 50% of torque specification. All the backshells were found to be hand loose at 10% of torque specification. The loop resistance value was never recorded to be out of range for any of the test panels. The backshells of all the test panels were not found to be thread loose during all stages of testing. Loop 2 of test panel 3 was not considered for testing, indicated as (-) in the table, because it was not fit for testing (see pretest conditions).

TABLE 6. CONNECTOR BACKSHELL LOOSENING BY TORQUE SPECIFICATION (BACKSHELL TYPE B)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell (Percentage of Torque Specified) | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 75% | 50% | 25% | 10% |
| | | Avg. Airbus LRT (m Ω) | | 82.5 | 88.17 | 94.33 | 94.7 | 98.9 |
| | | Thread Loose (Y/N) | | N | N | N | N | N |
| | | Hand Loose (Y/N) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 1 | 0 | 6 | 18 | 18 | 36 |
| | | Angle offset (degrees) | 2 | 0 | 6 | 6 | 6 | 18 |
| | 2 | | 3 | 100% | 100% | 100% | 100% | 100% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Avg. Airbus LRT (m Ω) | | 72.1 | 74 | 73.76 | 75.33 | 78.3 |
| | | Thread Loose (Y/N) | | N | N | N | N | N |
| | | Hand Loose (Y/N) | | N | N | N | Y | Y |
| | | Angle offset (degrees) | 3 | - | - | - | - | - |
| | | Angle offset (degrees) | 4 | 0 | 24 | 30 | 42 | 60 |
| 3 | 1 | | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 100% | 100% | 100% | 100% |
| | | Avg. Airbus LRT (m Ω) | | 25.23 | 25.05 | 25.5 | 26.56 | 27.36 |
| | | Thread Loose Y/N) | | N | N | N | N | N |
| | | Hand Loose (Y/N) | | N | N | N | N | Y |
| | | Angle offset (degrees) | 1 | 0 | 6 | 24 | 36 | 42 |
| | | Angle offset (degrees) | 2 | - | - | - | - | - |
| | 2 | | 3 | 100% | 75% | 50% | 25% | 10% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | Avg. Airbus LRT (m Ω) | | 30.6 | 32.8 | 31.6 | 33.53 | 34.05 |
| | | Thread Loose (Y/N) | | N | N | N | N | N |
| | | Hand Loose (Y/N) | | N | N | N | Y | Y |
| | | Angle offset (degrees) | 3 | 0 | 6 | 12 | 42 | 48 |
| | | Angle offset (degrees) | 4 | 0 | 6 | 6 | 24 | 60 |

TABLE 6. CONNECTOR BACKSHELL LOOSENING BY TORQUE SPECIFICATION (BACKSHELL TYPE B) (Continued)

| Test Panel | Loop No. | Measurement Techniques | Backshell No. | Connector Backshell (Percentage of Torque Specified) | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 1 | Avg. Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N)<br>Angle offset (degrees)<br>Angle offset (degrees) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 100% | 100% | 100% | 100% |
| | | | | - | - | - | - | - |
| | | | | - | - | - | - | - |
| | | | | - | - | - | - | - |
| | | | 1 | - | - | - | - | - |
| | | | 2 | - | - | - | - | - |
| | 2 | Avg. Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N)<br>Angle offset (degrees)<br>Angle offset (degrees) | 3 | 100% | 75% | 50% | 25% | 10% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | | | 26.5 | 23.7 | 25.1 | 26.4 | 29.2 |
| | | | | N | N | N | N | N |
| | | | | N | N | N | Y | Y |
| | | | 3 | 0 | 12 | 18 | 48 | 72 |
| | | | 4 | 0 | 12 | 30 | 42 | 78 |
| 6 | 1 | Avg. Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N)<br>Angle offset (degrees)<br>Angle offset (degrees) | 1 | 100% | 75% | 50% | 25% | 10% |
| | | | 2 | 100% | 100% | 100% | 100% | 100% |
| | | | | 21.3 | 21.5 | 21.6 | 22.1 | 23.1 |
| | | | | N | N | N | N | N |
| | | | | N | N | N | N | Y |
| | | | 1 | 0 | 6 | 18 | 36 | 48 |
| | | | 2 | - | - | - | - | - |
| | 2 | Avg. Airbus LRT (m Ω)<br>Thread Loose (Y/N)<br>Hand Loose (Y/N)<br>Angle offset (degrees)<br>Angle offset (degrees) | 3 | 100% | 75% | 50% | 25% | 10% |
| | | | 4 | 100% | 75% | 50% | 25% | 10% |
| | | | | 22.2 | 22.1 | 22.5 | 23 | 24.6 |
| | | | | N | N | N | N | N |
| | | | | N | N | N | Y | Y |
| | | | | 0 | 6 | 18 | 24 | 36 |
| | | | | 0 | 6 | 12 | 18 | 30 |

Figures 19 through 22 are graphs of percentage torque versus loop resistance for each test panel of backshell type A. Loop resistance values for loops 1 and 2 are plotted separately for each test panel. Arrows illustrate the observations for visually loose and hand loose. The backshells of all the test panels were not found to be thread loose during all stages of testing.

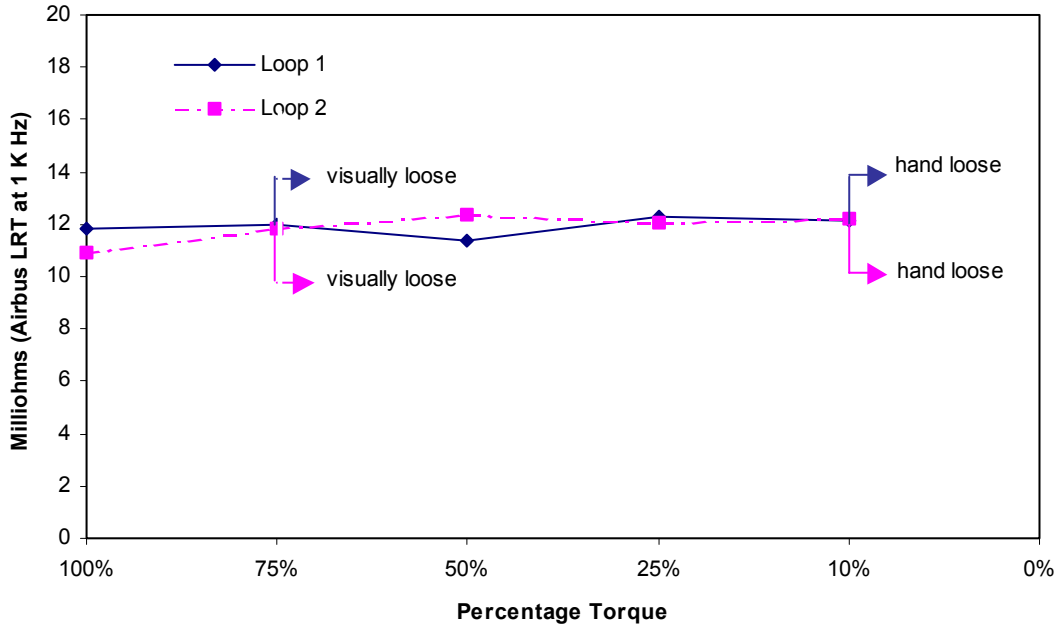


FIGURE 19. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 1 (BACKSHELL TYPE A)

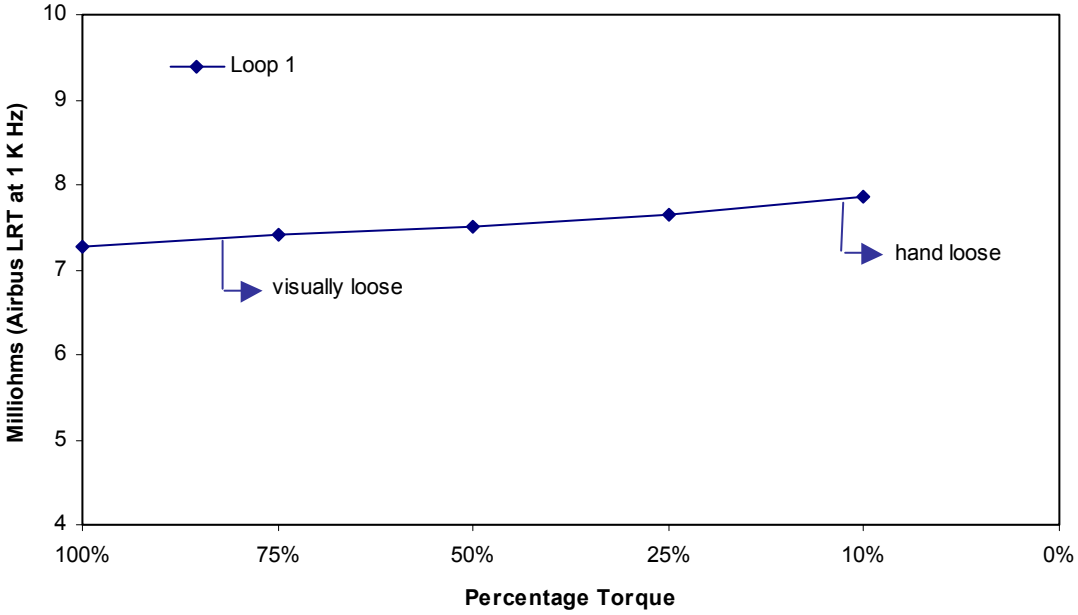


FIGURE 20. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 3 (BACKSHELL TYPE A)

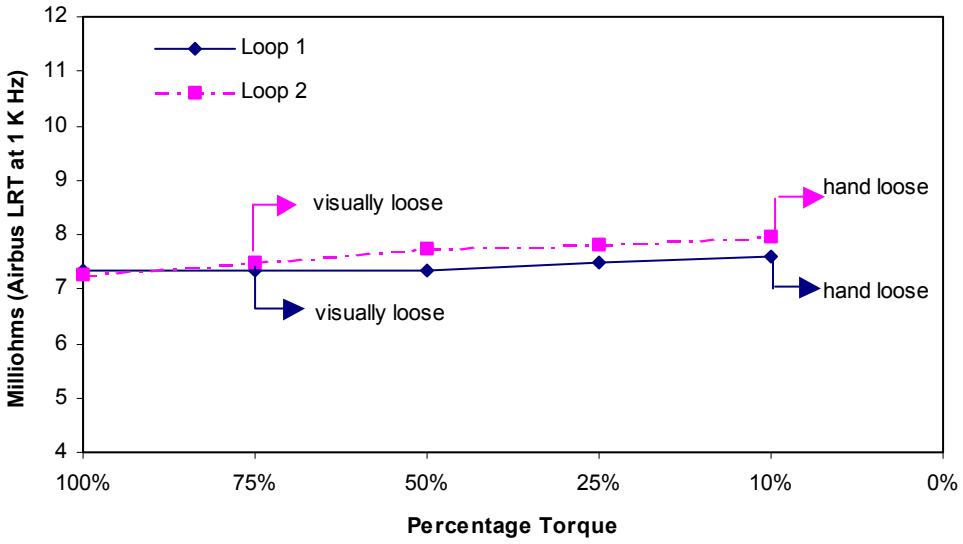


FIGURE 21. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 4 (BACKSHELL TYPE A)

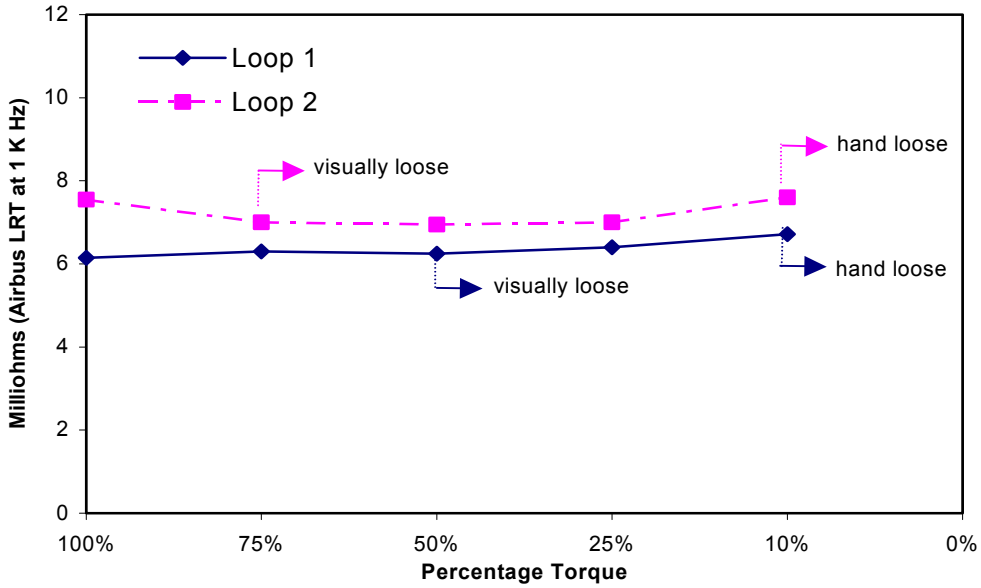


FIGURE 22. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 6 (BACKSHELL TYPE A)

All type B backshells were found to be visually loose at 75% of torque specification. The loop resistance value was never recorded to be out of range for any of the test panels. The backshells of all the test panels were not found to be thread loose during all stages of testing. Loop 1 of test panel 4 was not considered for testing, indicated as (-) in the table, because it was not fit for testing (see pretest conditions). Loop 1 of other test panels was found to be hand loose at 10% of torque specification while loop 2 became hand loose at 25% of torque specification.

Figures 23 through 26 are graphs of percentage torque versus loop resistance for each test panel of backshell type B. Resistance values for loops 1 and 2 are plotted separately for each test panel. Arrows illustrate the observations for visually loose and hand loose. The backshells of all the test panels were not found to be thread loose during all stages of testing.

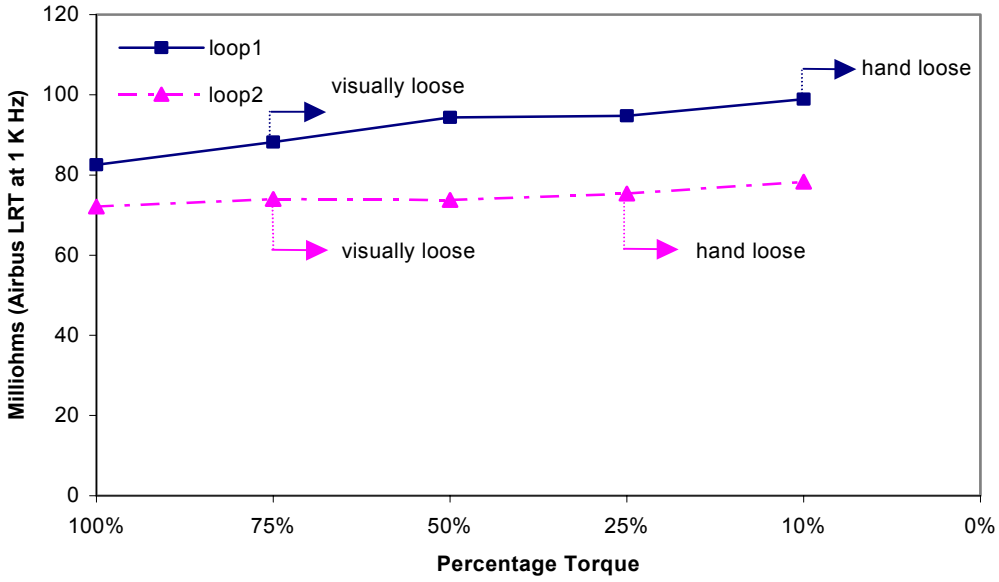


FIGURE 23. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 1 (BACKSHELL TYPE B)

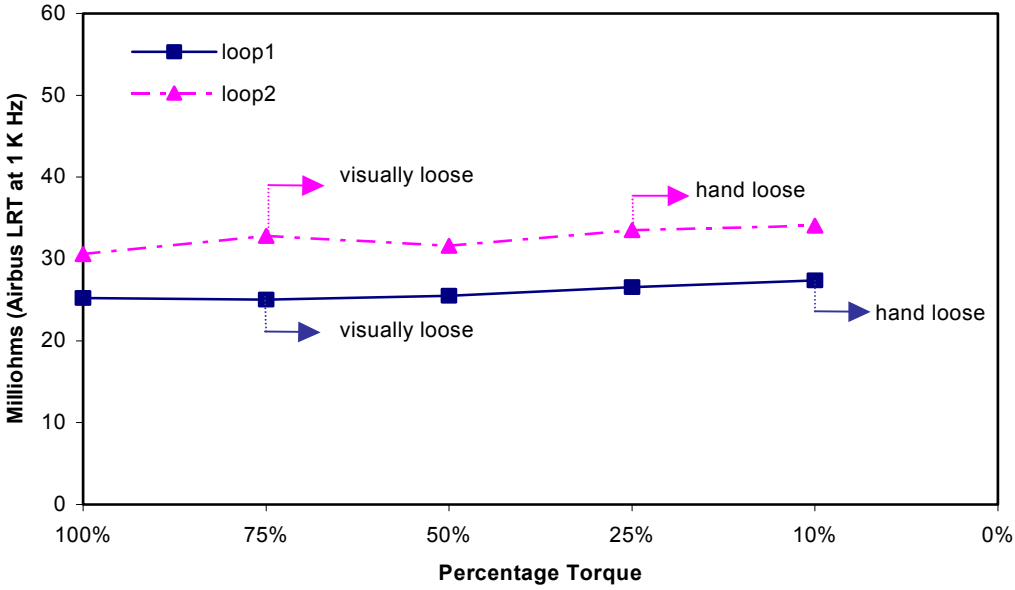


FIGURE 24. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 3 (BACKSHELL TYPE B)

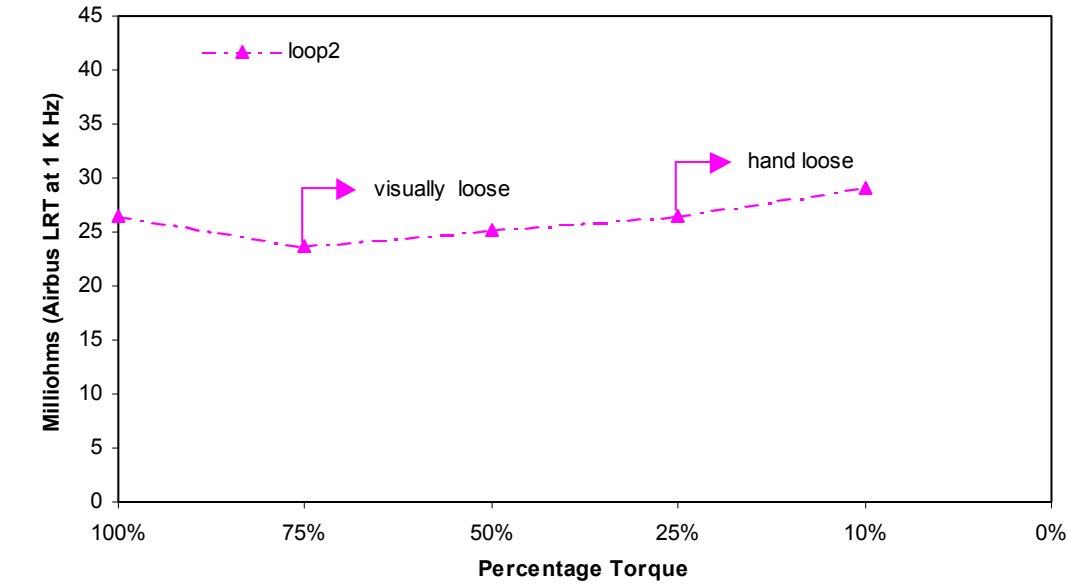


FIGURE 25. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 4 (BACKSHELL TYPE B)

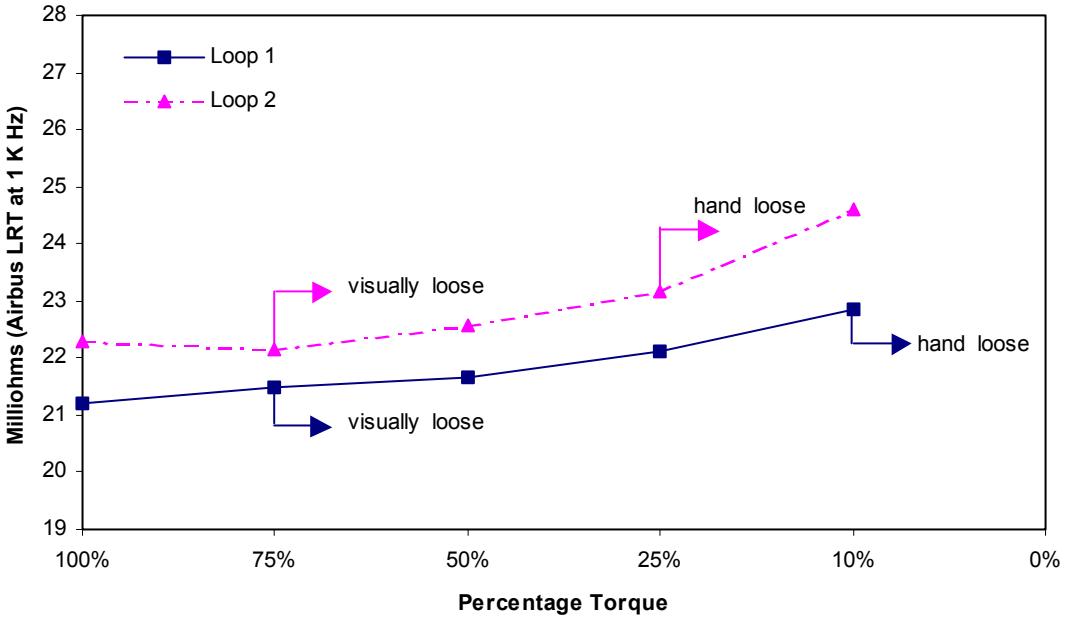


FIGURE 26. BACKSHELL LOOSENING BY TORQUE SPECIFICATION, TEST PANEL 6 (BACKSHELL TYPE B)

2.3.2 Observations.

The results of the above testing can be summarized as:

- All but one of the backshells were found to be visually loose when they were tightened to 75% of specified torque or less. The other was visually loose at 50% torque.
- Backshells were found to be hand loose when they were tightened to 10% of specified torque or less.
- The loop resistance never reached an open circuit for any of the test panels throughout the torque degradation testing.

# 3. OBSERVATIONS AND RECOMMENDATIONS.

## 3.1 OBSERVATIONS.

Data analyses of the test results demonstrated the following.

- Loosening of an aircraft wiring harness connector backshell will eventually result in a significant reduction of shield effectiveness, as measured by a marked increase in the shield loop resistance of the wire bundle.
- The backshells of all the test panels became visually loose before they were observed to be thread loose or hand loose.
- Backshell type A became ***visually loose*** and ***hand loose*** before any significant increase in shield loop resistance was electrically measured.
- Backshell type B became visually loose and also hand loose before, or at the same point, any significant increase in shield loop resistance was electrically measured.
- The backshells were detected to be hand loose prior to or at any abrupt change in the loop resistance value. Therefore, a check for hand looseness also serves as an alternative to check for visual looseness.
- A backshell cannot be observed to be thread loose if the initial position of the backshell is not known.
- Careful visual inspection can detect and pinpoint a loose backshell before a significant increase in electrical shield loop resistance is measurable.
- The check for visual looseness and hand looseness is only possible if the wiring harness connector backshells are visually and physically accessible on the aircraft.
- Loop resistance measurements on an accessible part of a harness, performed by a skilled operator, can detect a significantly loose backshell, but may not pinpoint its location.

## 3.2 RECOMMENDATIONS.

Based on the above observations, the following is recommended.

- Connector backshells should be checked for looseness during scheduled maintenance.
- A visual inspection using a mark reference, to indicate any loosening of the backshell, is the most effective method for the two types of backshells studied. This mark can be made with a wax/silicon bead, a permanent marker, etc. If the backshells are not marked, a check for hand looseness should be performed during scheduled maintenance.
- A visual inspection with no mark reference (thread loose) is not efficient in determining backshell looseness.
- A loop resistance measurement should be made on wire bundles when their backshells are not visually or physically accessible during routine maintenance.
- Due to the variance found in the test results between the two different types of backshells, a further study is recommended in order to propose maintenance procedures for a wide variety of backshells.

## 4. GLOSSARY.

Airbus LRT—An Airbus Loop Resistance Tester (LRT) is a device used to measure the loop resistance without disturbing the connectors.

Baseline Test—The initial test performed on the test panels before they are subjected to any further degradation tests.

Hand Loose—Each backshell was torqued to the manufacturer's specification and connected to the test panel. They were then checked for hand looseness by applying a force in the opposite direction by hand. During different stages of testing, the hand force was applied after the backshell was fitted back on the test panel. As soon as the backshell was movable by hand, it was declared ***hand loose***.

Test Panel—The setup used to carry out the laboratory tests.

Thread Loose—The initial visible threads on the backshell were taken as a reference after torquing the backshell to the manufacturer's specification. During different stages of testing, the backshell was visually observed, and as soon as an additional thread was clearly seen, the backshell was declared ***thread loose***.

Visual Inspection—Procedure adopted to check for physical degradation.

Visually Loose—The backshell and connector were marked after torquing the backshell to the manufacturer's specification. During different stages of testing, the backshell was visually observed, and as soon as there was a deviation from the mark reference, it was declared ***visually loose***.